913. 551. 8600 1:30
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EPA received written comments from the Missouri Coalition for the Environment on March 15, 2013. The comments were provided in a document titled "Risk and Character of Radioactive Waste at the West Lake Landfill, Bridgeton, Missouri" by Robert E. Criss of Washington University of St. Louis, March 14, 2013. These comments reflect the points that the author made orally at EPA's public meeting on January 17, 2013. The following is EPA's response.

1. Chemical and physical character of the radioactive material

The commenter speculates that "...complete analyses of the original radwaste, and possibly even actual samples of the leached barium sulfate exist today." EPA is unaware of any samples of or analytical results for the "original radwaste" that might exist, and does not have any such samples or analytical results in its possession. All of the information EPA has on how the radiological waste came to be in the West Lake Landfill was provided by the Nuclear Regulatory Commission, primarily in its reports of 1976, 1982 and 1988.

The commenter states his disagreement with the NRC's conclusion that the radiological material at West Lake Landfill is leached barium sulfate residue, basing this opinion on the barium to sulfate ratios in NRC's samples. EPA disagrees with this view. The commenter overlooks the fact that the NRC's samples did not represent the original leached barium sulfate residue generated by Mallinckrodt's ore processing facility. Information reflected in public records indicate the residue had been mixed with 39,000 tons of soil of an unknown composition, spread over and incorporated into two large municipal solid waste landfill cells, and left uncapped for at least three years before NRC collected its first samples in 1976. Given that NRC collected samples three years after the barium sulfate was disposed and that the barium sulfate was mixed with other soils at the landfill, the barium to sulfate ratios of the NRC's samples would not necessarily match the stoichiometric ratio of pure barium sulfate ($BaSO_4$).

EPA would prefer that samples of the original residue had been analyzed, but this does not call into question EPA's investigation and decision-making for the site. NRC has well-established expertise in assessing radiological sites, and while there is speculation by the commenter to the contrary, there is no credible evidence to refute NRC's conclusion that leached barium sulfate residue was placed in the West Lake Landfill.

2. Radiological character of waste

The commenter discusses the decay of thorium and the ingrowth of radium over time as these two elements re-establish the secular equilibrium of their decay series. EPA does not dispute the comments. The commenter describes a well-known process which was discussed in Section 2.2.7 of the final Supplemental Feasibility Study report as well as earlier documents. The increase in radium activity with time was fully considered in the landfill cap design presented in the SFS report. The commenter raises no new issues here. In fact, this issue was raised during the public comment period on the proposed plan and addressed in the responsiveness summary for the 2008 OU-1 ROD.

3. Nature of the landfill

The commenter restates facts about the landfill waste and distribution of the radiological contamination in the OU-1 cells and the subsurface fire in one of the OU-2 cells that is more than 1,000 feet away from

the nearest radiological contamination. EPA agrees in part but disagrees with the claims presented in points (1), (3) and (5) about effects the OU-2 fire could have on the OU-1 radiological contamination. The commenter raises the possibility of "particulates" or "smoke" being released from the subsurface fire and carrying radiation away from the site. EPA notes that the FEMA reference cited here discusses both surface and subsurface fires. To the best of EPA's knowledge, the OU-2 subsurface fire has caused gas releases but not particulate releases [NOTE: checking with MDNR]. With the exception of radon, the radionuclides and their decay products (and their oxide compounds) in the landfill are non-flammable solids with very high melting points that will not become gases. In addition, the waste mass in OU-1 Area 1 is considerably older, smaller, and shallower than that in the OU-2 cell which is currently on fire, so it is extremely unlikely that a subsurface fire could independently start in this cell or propagate into this cell from the adjacent OU-2 cell. However, in the interest of addressing public concerns on this issue, EPA will review available data on the effects of subsurface landfill fires on hazardous substances (including radionuclides) to determine what effects such a fire might have on the OU-1 Area 1 cell.

4. Hydrologic and Geologic Risk Factors of the West Lake Landfill Site

The commenter reiterates concerns about potential flood and earthquake risks to the site that were raised and addressed in the public comment period and 2008 OU-1 ROD responsiveness summary. As EPA has stated previously, the cap-in-place remedy selected in the 2008 OU-1 ROD does not depend on the integrity of the Earth City Levee system. Portions of the toe of the OU-1 Area 2 radiologically-contaminated cell would be armored with rip-rap (large boulders) to prevent erosion of the cap in the event that the levee failed or was overtopped by a "greater-than-500-year" flood event. Due to fill activities, the West Lake Landfill is now the highest area in Earth City, and its elevation is substantially above the top of the Earth City levee. Specifically, the topographic relief from the river to the landfill is about 55 feet.

The commenter asserts that the site has "high" liquefaction potential. EPA disagrees. The assertion is not supported by the reference cited, which is an MDNR Earthquake Hazards Map for the St. Louis metro area. This map shows **all** areas built on alluvial deposits from the Missouri and Mississippi rivers as having "potential for liquefaction and/or soil amplification". Also, the assertion that the site is near areas that have "significant" landslide potential is unsupported by this reference, which identifies sloped areas throughout the metro area as having "potential for landslide". The risks for liquefaction or landslide at the site are no greater than those anywhere else along these rivers.

EPA disagrees with the statement that the erosional events on the toe of OU-1 Area 2 were caused by a slope failure or landslide rather than surface erosion. Historical aerial photos of the area show no evidence of a slope failure, ground scarp or landslide, but do show material eroding off of the Area 2 toe onto the adjacent Buffer Zone/Ford Property. The re-evaluation of the ROD cap-in-place remedy in the SFS includes regrading of the landfill, primarily to reduce the steepness of the slopes on the perimeters of OU-1 Areas 1 and 2, to further reduce the risk of future erosion events.

The 2008 OU-1 ROD remedy of capping in place includes cap maintenance in perpetuity which would repair any future damage caused by surface erosion, settling (due to earthquake-induced liquefaction or other causes), desiccation cracking, or any other processes.

5. Groundwater Contamination

The commenter reiterates concerns about potential contaminant migration to the underlying aquifer that were raised and addressed in the public comment period and 2008 OU-1 ROD responsiveness summary. The commenter's statement about the lack of a protective cap and basal liner appears to argue for the installation of a cap, consistent with the 2008 OU-1 ROD remedy. As stated in the responsiveness summary, general comment 5, "It is important to understand that it is the cover, not a liner, which prevents surface water from contacting the waste material." It is surface water infiltration which generates leachate that can then migrate out of the landfill waste.

While some historical diagrams such as the one cited here by the commenter do show groundwater in contact with portions of the deepest municipal solid waste in the OU-1 landfill cells, it is important to note that little if any of the deepest waste is radiologically contaminated. Soil samples and vertical gamma profiling data collected from borings during the OU-1 Remedial Investigation and re-evaluated in greater detail in the SFS, show the three-dimensional extent of the radiological contamination within the overall waste mass. The commenter's final sentence in this section misinterprets the radionuclide data from the 2012 groundwater sampling event, as discussed in more detail below.

6. Groundwater migration

The 2012 groundwater sampling event results show radium in groundwater at levels above its MCL in more locations than were found in the sampling events prior to the OU-1 ROD in 2008. It is not clear at this time whether or not these results represent contamination migrating from the landfill for the following reasons.

(a) 2012 was a year with significantly lower than normal precipitation, which led to significantly less water infiltrating the OU-1 wastes. As discussed above, it is surface water infiltration which creates leachate that can potentially transport contaminants out of the waste mass. A drier year would be expected to create less leachate, reducing potential transport of contaminants out of the waste rather than increasing it, and lowering groundwater concentrations of waste-derived contaminants rather than increasing them.

(b) Detections of radium in groundwater above its MCL were found across the site, in both shallow and deep wells, in locations both downgradient and upgradient of the OU-1 cells. There are also numerous wells across the site, both shallow and deep, in locations both downgradient and upgradient of the OU-1 cells, that contain radium in groundwater substantially below its MCL. There is no credible plume geometry or hydrologic system that can explain this site-wide distribution of radium contamination in groundwater as originating from the OU-1 cells. The disagreement between the commenter and EMSI over whether PZ-101-SS is downgradient or upgradient of OU-1 Area 1, due to the hydraulic draw-down from the leachate collection system at the former Active Sanitary Landfill, overlooks the larger site-wide distribution of radium contamination in groundwater.

(c) Uranium and thorium, the other radiological contaminants in the OU-1 cells, were not found at elevated concentrations in the groundwater across the site. Uranium did not exceed its MCL in any of the wells sampled in 2012, and thorium (which does not have an MCL) was found in dissolved samples at a maximum concentration of 2.04 pCi/L. Even accounting for the different solubilities of radium,

thorium and uranium compounds in the landfill waste, the commenter's assertion that "...radionuclides are actively migrating in the groundwater..." cannot explain why only radium is exceeding its MCL in groundwater across the site.

(d) The isotopic abundances of radium in the landfill waste do not match those of radium found in the groundwater samples. Both Ra-226 and Ra-228 are found in the groundwater samples at fairly comparable concentrations, while the OU-1 soil samples contain primarily Ra-226 with little to no Ra-228. Leachate generation and migration would not alter these isotopic abundances.

The commenter also discusses several different historical and current estimates of the hydraulic conductivity and flow velocity at the site. It is not unexpected that these estimates do not exactly match, due to differing methodologies for calculating these values and heterogeneity in the aquifer materials. Furthermore, demonstrating that an aquifer has a high hydraulic conductivity and flow velocity does not by itself mean that there is a groundwater contaminant plume at the site.

It is EPA's position that the 2012 groundwater data do not prove or disprove the existence of a groundwater contaminant plume at the site. For this reason EPA has requested that the PRPs conduct three additional rounds of groundwater sampling in 2013 to provide a more comprehensive picture of current groundwater conditions at the site.

7. Background Radiation Levels

It is EPA's position that the 2012 groundwater data by itself does not prove or disprove a background source for radium in groundwater at the site. EPA will obtain assistance from the US Geological Survey, whose papers were cited by the commenter, to understand and interpret the groundwater results from the 2012 and upcoming 2013 sampling events and determine the background contribution to contaminant concentrations in the aquifer beneath the site.

8. Assessment and Recommendations

The commenter reiterates the points made earlier in the document, which have already been addressed above.

The commenter's suggestion here that samples of the radiologically contaminated material within the landfill should be dug up and analyzed now to obtain results indicative of the original barium sulfate waste is not sound scientifically. This material has been in contact with a diverse mixture of soils, municipal solid waste, and other wastes in uncontrolled conditions for the past forty years. The original radiological material has been unavoidably altered by this contact, and there is no way the material could be reliably "re-constituted" now.

The commenter recommends "several dozen new monitoring sites ... at least 1000 feet away from the landfill boundaries". EPA disagrees. Based on available data, there is no justification for the "several dozen new monitoring sites ... at least 1000 feet away from the landfill boundaries". However, regardless of the remedy eventually selected for OU-1, the site will always be a landfill and thus will require groundwater monitoring and Five-Year reviews for the foreseeable future. If future groundwater

results definitively demonstrate a contaminant plume at the facility boundary, off-site monitoring wells would be installed as necessary to define the plume and help select a groundwater remedy.